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THE GLASS INDUSTRY

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THE CHEMISTRY OF COLORED GLASS[1]

By DR. ING. WOLDEMAR WEYL[2]

ABSTRACT

The chemical reactions involving colored ions in glasses are discussed on the basis of the absorption spectra.

The solvation of the colored ions gives rise to a change in fine structure and to a shift of the absorption bands in glasses relative to those in aqueous solutions.

Dissociation-association equilibria between complexes containing the central ion in different states of coordination are responsible for the color change of nickel and cobalt glasses. This effect is compared with the influence of the coordination number on the color of crystals. The rapidly increasing viscosity of glasses in the softening range permits the "freezing in" at ordinary temperatures of dissociation equilibria of high temperatures.

For some characteristic coloring oxides, the oxidation-reduction equilibria are described and the factors which affect these equilibria are explained. A table of relative oxidizing powers of certain important oxides in glass is presented. The mutual interaction of coloring ions among each other and with arsenic has been discussed with the aid of several examples. An explanation is given of the behavior of the glasses exposed to sunlight. It is shown that discoloring may be attributed to the existence of excited states of the coloring ions.

Finally, the possibilities of developing new colored glasses are pointed out.

In the development of glass research during the last half century, a remarkable shift has taken place from the originally purely chemical conception of glass as a mixture of oxides, silicates, and borates to a preponderantly physical one. This is partly due to the discovery that some of the characteristic properties of glasses are essentially independent of the chemical nature of the glass-forming compounds. It is also due to the fact that the glassy state of silicates could not only be extended to borates, phosphates, and similar salts, but even to elements and organic compounds.

As interest in physical considerations of the "vitreous state" became greater and greater, emphasis on the chemistry of glass diminished. This shift of emphasis to the physical side of the problem has been favored by the fact that in the recent development of natural sciences in general, chemical processes have been treated more and more from the physical viewpoint. Just as the medical and biological fields have been aided by the application of modern chemistry, so chemistry itself has been aided by the application of modern physics. This trend of the natural sciences has undoubtedly contributed to the fact that the chemistry of glasses has been somewhat neglected.

The present-day description of the structure of glass with the nomenclature which has heretofore been used only for the crystalline state is justified by the recent development of our knowledge of the liquid state and by x-ray studies on glasses. Liquids not far above the melting point resemble the crystalline state much more than they do the gaseous state. The x-ray data on glasses seem to be accounted for without postulating the existence of definite molecules. It is not reasonable, however, to deny the existence of molecules in the glassy state merely because the term molecule has no significance in many ionic crystals.

The main contribution of the present paper is in the emphasis of the chemical reactions which take place in glass. It seems to the author that no other field of glass research is better suited to this purpose than the field of colored glasses. The chemical reactions in making colored glasses will be emphasized, and therefore this paper will concern itself only with the ionic colors; the field of colloidal colors will be omitted.

The discussion will be chiefly devoted to the investigations of the author and his collaborators, E. Kreidl, C. Kühl, H. Pfeilschifter, H. Rudow, and E. Thümen. These researches have been carried out during the last five years in the Kaiser Wilhelm Institut für Silikatforschung, Berlin-Dahlem. No attempt is made to describe all the results in detail. Some typical examples are selected, and in these the processes which take place in making colored glasses are discussed. The ways in which these processes may influence the color are also discussed.

● Because of the thoroughness of Dr. Weyl's distinguished work it has been found necessary to publish his findings in three separate instalments.

The first instalment, presented here, will be of an introductory nature and will include theoretical considerations. This will cover the origin of the absorption spectrum and its change under the influence of the solvent as well as present dissociation-association equilibria between coloring complexes.

The April issue will present some important coloring oxides and their oxidation-reduction equilibria.

In May, will be presented the mutual interaction of coloring oxides of different valencies among each other and with other arsenic oxides. Dr. Weyl at this time will also discuss the possibilities of developing new colorants.

[1] A comprehensive bibliography concerning the mechanism of color formation, was published by F. H. Norton, THE GLASS INDUSTRY, Feb., 1935.

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1. Theoretical Considerations — Origin of the Absorption Spectrum

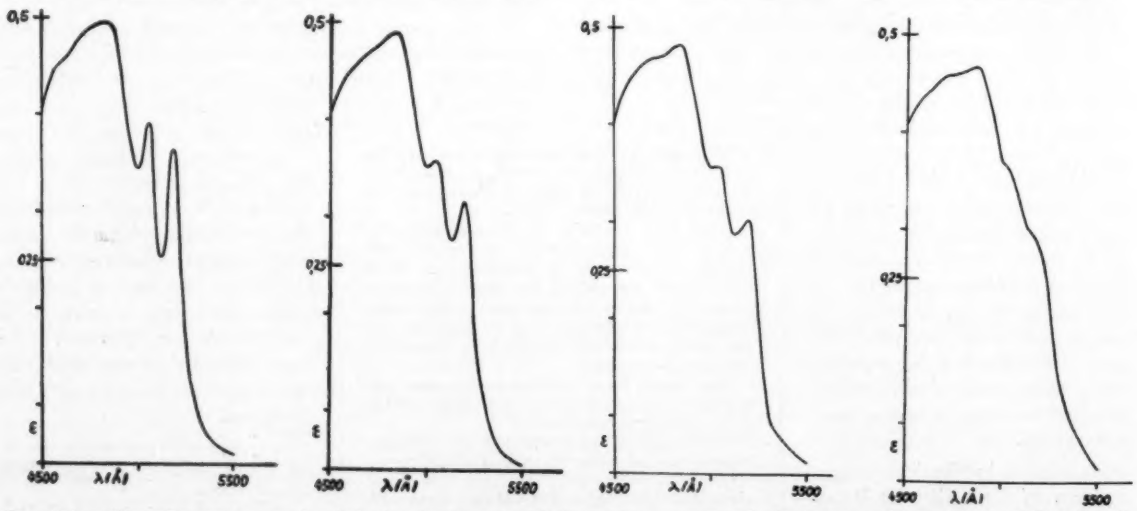
White light may be defined as light which contains all the wave lengths of the visible spectrum. If white light is allowed to pass through a colored solution or a colored glass, the light which emerges appears colored to our eyes. The reason for this is that in passing through the solution or glass, certain wave lengths in the incident white light are more strongly absorbed than others and so the emergent light has a different intensity distribution. The property of a glass or a solution to absorb light selectively, that is, to absorb certain wave lengths more strongly than others, may be quantitatively described in different ways. For light filters, signal and eye protecting glasses it is sufficient to give the percentage of light transmitted for the different regions of the spectrum. On the other hand, for physical-chemical considerations it is more convenient to give the spectral absorption curves, that is, the dependence of the extinction coefficient upon the wave length.

Theoretical considerations of the mechanism of light absorption from the atomistic viewpoint lead to the conclusion that only definite wave lengths can be absorbed. The resultant absorption spectrum should therefore consist of a definite number of dark lines with a colored background. Such an absorption spectrum, in which the lines are very sharp, is obtained in the case of dilute gases and vapors. For liquids and glasses, however, a more diffuse spectrum is to be expected, and this is actually observed. In fact, in these cases, the spectrum cannot be resolved sufficiently to obtain discrete lines.

At the present time, we know that this broadening of spectral lines is due to the perturbing effect of the electrical fields of the surrounding solvent molecules on the absorption process of dissolved ions or molecules. This knowledge is of particular importance, for it follows that the absorption of any coloring ion will be influenced by the electrical properties of the solvent. One and the same dyestuff may color different solvents in different ways. A well known example is iodine dissolved in various solvents. A solution of iodine in chloroform or carbon disulfide is purple whereas a solution of iodine in benzene or toluene is red and a solution of iodine in ether or alcohol is brown. Further conclusions on the influence of the solvent may be drawn by a quantitative determination of the spectral absorption. Upon this basis, all color changes may be divided into three different types, viz. the disappearance of the fine structure, the shift of the absorption band, and the occurrence of a new band. These will be discussed separately.

Change in the fine structure—The less the perturbing influence of the solvent molecules surrounding the solute molecules which absorb the light, the more does the spectrum resemble the line spectra obtained for gases. In other words, the spectrum shows a certain degree of fine structure. On the other hand, as the perturbation due to the solvent molecules becomes larger, the fine structure gradually disappears, and a diffuse absorption band results. As an example of this general broadening effect of a solvent, the spectral absorption of quinizarine may be mentioned. This organic compound has a characteristic absorption spectrum when dissolved in hexane. The spectrum consists of two narrow bands in the short wave length region. If alcohol or nitrobenzene is added to such a solution, a perturbation arises, and as a result, the spectrum becomes more and more diffuse, until both bands disappear (Figs. 1-4). This effect is not very noticeable to the naked eye, for our eyes perceive only general color impressions and not the fine structure. Nevertheless, it may be mentioned that the sharper the absorption spectrum the clearer and brighter the color appears. Broadened absorption bands generally give rise to a grayish or brownish color.

Shift of the absorption band—A comparison of the absorption spectrum of iodine in hexane and in other solvents shows that the shape of the absorption curve does not change very much from solvent to solvent. The absorption maximum is shifted, and this shift is primarily responsible for the color change from purple to red. The spectra of iodine in various mixtures of hexane and benzene show this very clearly. In pure hexane, the maximum absorption occurs at 525 $m\mu$, and in pure benzene it occurs at 500 $m\mu$. With this shift is a general broadening due to the perturbing action of the polar solvent.



Figs. 1-4. *Absorption spectrum of quinizarine in hexane with increasing amounts of nitrobenzene. From left to right: Fig.* 1, *hexane; Fig.* 2, *hexane plus* 7 *per cent nitrobenzene; Fig.* 3, *hexane plus* 13 *per cent nitrobenzene; Fig.* 4, *hexane plus* 60 *per cent nitrobenzene.*

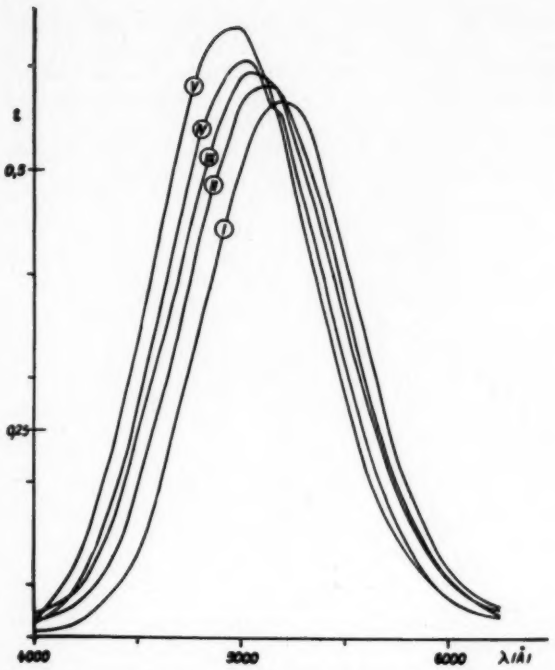


Fig. 5. Absorption spectra of iodine in hexane-benzene mixtures.

I.	*Hexane*						*λ max.*	= 525 mμ
II.	"	*plus*	14.3	*per*	*cent*	*benzene*	"	= 515 "
III.	"	"	28.6	"	"	"	"	= 507 "
IV.	"	"	54.5	"	"	"	"	= 505 "
V.	——		100.0	"	"	"	"	= 500 "

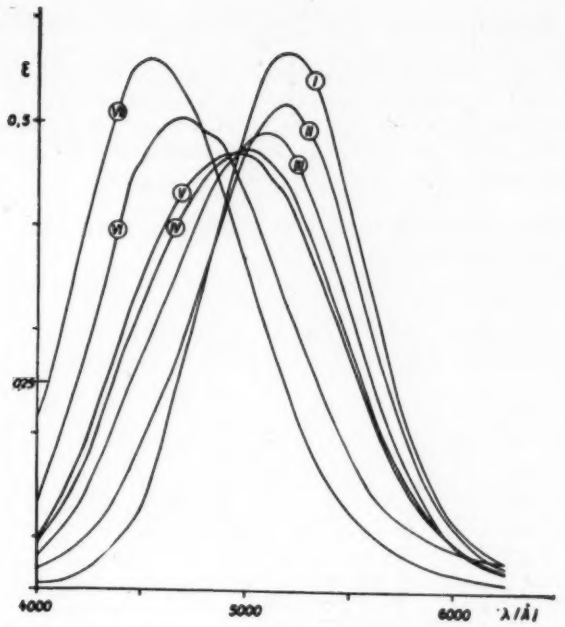


Fig. 6. Absorption spectra of iodine in hexane-ether mixtures.

I.	*Hexane*	*plus*				*Ether*	*λ max.*	= 525 mμ
II.	"	"	2.28	*per*	*cent*	"	"	= 520 "
III.	"	"	4.56	"	"	"	"	= 510 "
IV.	"	"	7.15	"	"	"	"	= 500 "
V.	"	"	8.60	"	"	"	"	= 493 "
VI.	"	"	28.60	"	"	"	"	= 465 "
VII.	——		100.00	"	"	"	"	= 450 "

Occurrence of a new band—The above mentioned phenomena are caused by the electrostatic effect of solvent molecules upon the solute. The effects are more pronounced the greater the polarity of the solvent. There is, however, a possibility that a chemical reaction may occur between the solute and solvent. In this case the formation of a new molecular species gives rise to a new absorption band. As an example, Fig. 6 shows how the absorption spectrum indicates the formation of a molecular compound between iodine and ether.

As concentrated HCl, $CaCl_2$, or LiCl is added to a red aqueous solution of cobaltous chloride, the absorption of the cobalt cation is replaced by the typical absorption band of a negatively charged cobalt complex (Figs. 8 and 9).

Spectra rich in structure, such as quinizarine in hexane, are not very common in glasses. With the exception of some glasses containing uranium, only those glasses which are colored by the rare earth oxides of neodymium, praseodymium, and erbium give absorption spectra which show fine structure. F. Weidert and K. Rosenhauer studied the absorption of neodymium glasses in relation to the composition of the base glass. They found that the fine structure of a neodymium-rubidium glass decreases as the rubidium is replaced successively by potassium, sodium, and lithium (Fig. 7). The stronger the perturbation of the alkali ion, the greater is the broadening of the absorption band. For ions with the same charge, this effect increases with decreasing ionic size. It is therefore greatest for lithium and least for rubidium.

In optical filter glasses, e. g., in the yellow cadmium sulfide glass, a sharp absorption edge is often desirable. To achieve this, a base glass with as small a perturbing action as possible is desired. A potassium-barium glass, with its small perturbing effect on dissolved ions or dissolved cadmium sulfide molecules, is preferable to a soda-lime glass or a glass containing lithium.

For most glass colors, the substitution of one alkali by another causes a shift of the absorption band as well as a broadening, and therefore a color change analogous to that of a hexane-iodine solution when benzene is added. In this way, one can see why the purple color of manganese glasses, which is caused by the presence of trivalent manganese, is influenced by the base glass. In sodium glasses, the color is due to the different degree of solvation of the trivalent manganese ion which causes a shift in the absorption band.

Selenium pink, the color which is produced by a selenium in a molecular solution, is also influenced by solvation. When dissolved in glass, selenium has an absorption maximum at about 500 $m\mu$, the exact position depending upon the nature of the base glass. Upon this basis, it may therefore be seen why potassium glasses give the much preferred bluish pink, whereas sodium and especially lithium-containing glasses give rise to a yellowish-red tint.

In addition to the factors already mentioned, the solvent properties of glasses depend upon temperature. Manganese or selenium colors are shifted towards blue with increasing temperature. A selenium-soda glass at about 250°C has nearly the same color as a selenium potassium glass at room temperature.

In contrast to these relatively small changes of light absorption such as broadening the shift of absorption bands which are caused by solvation effects, we find

stronger color changes due to more intense chemical action.

Of all the possible chemical variations, those of the state of oxidation are best known. Here a complete analogy may be drawn between glasses and ionic colors of aqueous solutions. In the discussion of individual coloring oxides, further details will be given.

Dissociation-Association Equilibria Between Coloring Complexes

Influence of the base glass—It has heretofore been very difficult to offer a satisfactory explanation for the behavior of a certain class of glass colors. As an example, the coloring of glass with nickel oxide may be mentioned. The well known stability of the divalent nickel ion makes it rather improbable that there are two different states of oxidation of this metal in glass. Nevertheless, nickel produces a wider variety of colors than almost any other coloring oxide.

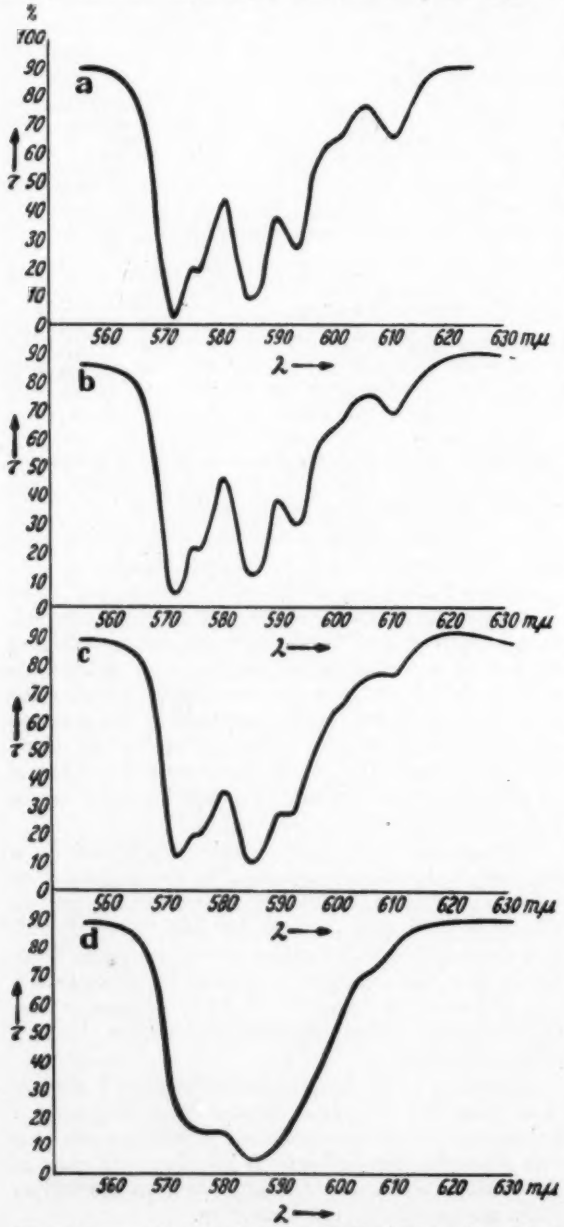


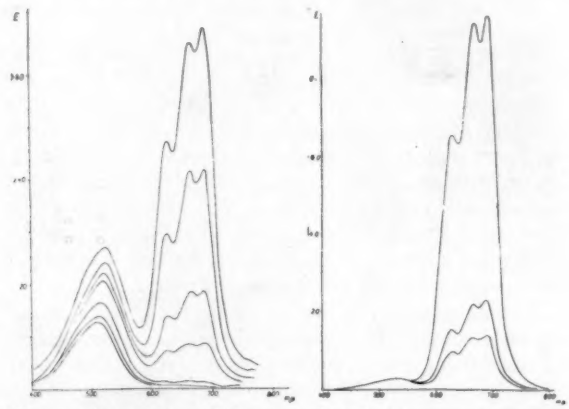
Fig. 7. Spectral transmission curves of Neodymium glass. (From F. Weidert and K. Rosenhauer.) a. Rubidium silicate glass; b. Potassium silicate glass; c. Sodium silicate glass; d. Lithium silicate glass.

P. P. Fedotieff describes the colors of different base glasses containing 0.3 per cent NiO as follows:

$PbO.SiO_2$	orange
$Li_2O.PbO.5SiO_2$	yellow
$Na_2O.PbO.5SiO_2$	reddish violet
$K_2O.PbO.5SiO_2$	bluish violet
$Na_2O.CaO.5SiO_2$	reddish violet
$K_2O.SrO.5SiO_2$	violet

It may be worth while to mention here that it is necessary to be very careful in interpreting glass colors, if only a description of the color is given without mentioning the concentration of the coloring substance in the base glass, the thickness of the glass, and the type of illumination used. Different absorption spectra are not necessarily the only explanation for different color impressions. Often physiological factors play a very important role. Solutions of chromium salts such as chrome alum show a color change from green to red with increasing concentration. Neodymium and nickel glasses are excellent examples which illustrate the origin of contradictory color descriptions given by earlier workers.

If a wedge is made from a sodium glass containing about 1 per cent nickel oxide, the color of the transmitted light changes from a yellowish gray in the thin



Figs. 8 and 9. Left to right: the influence of increasing amounts of lithium chloride on the absorption of an aqueous solution of cobaltous chloride.

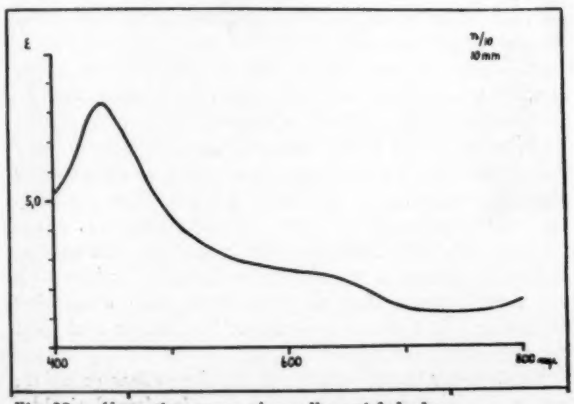
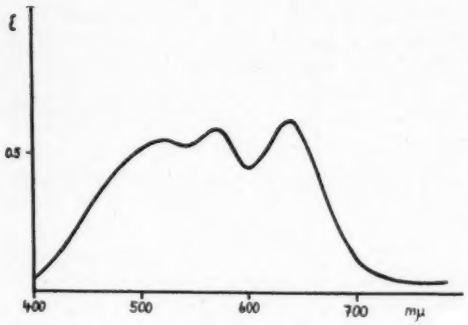
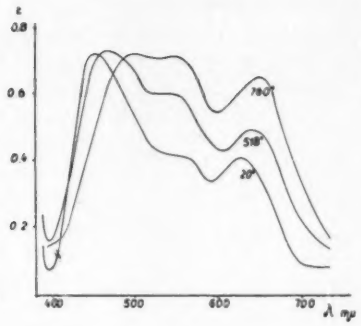


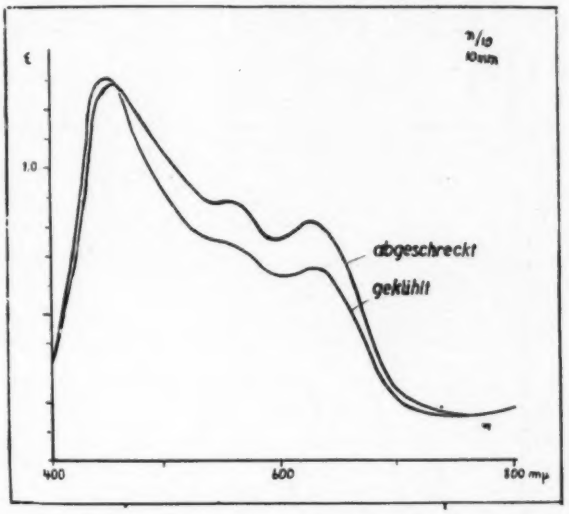
Fig. 10. Absorption curve of a yellow nickel glass.





Left: Fig. 11. Absorption curve of a purple glass. Right: Fig. 12. Absorption curve of a nickel-sodium-silicate glass at different temperatures.

Fig. 13. Below: Absorption curve of a nickel-sodium silicate glass with different heat treatment (chilled and cooled).



part to a purple in the thick part of the wedge. A similar wedge from a neodymium glass shows a transition from blue to red. These examples, chromium solutions, nickel and neodymium glasses also show a pronounced dependence of color upon the illumination. They appear to have different colors according to whether daylight or artificial light is used as the source of illumination, just as is the case for the precious stone alexandrite.

These physiological factors complicate the study of the dependence of the nickel color upon the composition of the base glass. In order to investigate these relations, more than 100 nickel glasses were melted and their spectral absorptions carefully examined. As base glasses, pure alkali silicates were chosen as well as glasses of the composition $Na_2O.RO.SiO_2$ and $K_2O.RO.SiO_2$. In the latter two cases, RO signifies any one of the following glass-forming oxides: CaO, SrO, BaO, BeO, MgO, CdO, ZnO, and PbO. In other series, increasing amounts of silica have been replaced by boric oxide and phosphoric acid. The colors of these glasses were quite varied. They varied between yellow, brown, gray, and deep purple.

A thorough analysis of the spectral absorption of all these glasses led to the conclusion that all the colors could be accounted for on the basis of two types and the superposition of both. Nickel oxide has the ability of producing the two extreme colors, yellow and purple, Normally, mixtures of the two occur. In lithium-silicate glasses, in metaphosphoric acid glasses, and in sodium borosilicate glasses rich in boric oxide, the yellow color prevails; in rubidium and potassium glasses the violet, or more correctly, the purple color is present (Figs. 10 and 11).

Influence of temperature—How can the occurrence of both colors be explained? Nickel glasses, melted under widely varying oxygen pressures, prove that the color is entirely independent of the pressure. The state of oxidation of nickel cannot be changed. Valuable information concerning this problem is obtained by studying the behavior of nickel glasses at different temperatures. It was observed that all glasses are purple at high temperatures, even those which later become yellow or gray. Fig. 12 shows the temperature dependence of the color of a nickel-sodium glass. This phenomenon is very similar to the behavior of some aqueous solutions which also show a reversible color change during heating and cooling. The change of color from red to blue of concentrated cobaltous chloride is well known. Just as in aqueous solutions, compounds also occur in glasses which contain the coloring atom with different coordination number. Following A. Werner (1893), the coordination number is here defined as the maximum number of nearest neighbors which can surround a given atom or ion under definite conditions. The actual number of atoms which surround a given atom may or may not be equal to the coordination number. If it is less, the atom is said to be unsaturated. The unsaturated compound of nickel in glass is purple; it is stable at high temperatures. With decreasing temperature, depending upon the composition of the base glass, a dissociation-association equilibrium occurs between the unsaturated purple and the saturated yellow complex.

Influence of heat treatment—In a glass, the particular equilibrium which is "frozen in" during cooling depends essentially upon the rate of cooling and upon the composition of the base glass. Without going into great detail, it may be stated that for pure alkali silicates, the nickel color will be changed from yellow (lithium silicate) to purple (rubidium silicate) with increasing ionic size of the alkali. The grayish color of some soda glasses is caused by superposition of the yellow and purple complexes. The study of these equilibria has led to some interesting conclusions concerning the structure of glass.

It has already been mentioned that the saturated yellow nickel complex dissociates with increasing temperature to form the unsaturated complex, probably by splitting off silicate or borate groups. Fig. 12 shows the spectral absorption of a nickel-soda glass at different temperatures. The spectrum at 20°C is due to an association-dissociation equilibrium in which the yellow (saturated) form is predominant (Fig. 10). At 518°C the unsaturated complex can be observed and at 760°C it

● *Left: A scene in the roof garden of the Waldorf-Astoria Hotel. The murals shown are of glass. Right: The Jansen Room, where many of the meetings will be held. The walls of this room are lined with mirrors.*

erously donated its entire program that night to American ceramics. In the opening announcement, the commentator will call attention to the fact that the members of the American Ceramic Society are meeting in New York. The program will be on the life of Stiegel, pioneer glass manufacturer in the United States. After the broadcast, there will be a special showing of the new duPont film, "The Wonder World of Chemistry." Two hundred tickets have been reserved for ACS members, who may secure them at the company's rooms in the Waldorf.

Since the "Cavalcade of America" cannot be seen by the entire meeting, tickets have been secured for other leading broadcasts. In passing, it should be mentioned that tickets to broadcasts are at a great premium in New York, and the committee has accomplished a noteworthy feat in providing so liberally for this meeting.

The broadcasting programs will most of them be finished by 10 o'clock. After that hour, if you want to find the crowd, go to the second show of the French Casino. It is hardly necessary to remark that the French Casino is considered the best show of its type anywhere, and its selection by the Entertainment Committee was sheer genius.

Curiously enough, this part of the program has no official status, since the Society has called Wednesday night "open." Probably this is because the Casino entertainment is not included in the $3.00 registration fee. It will be remembered that the registration fee originally was fixed at $5.00, and subsequently reduced to $3.00. This was done in order to give members of the Society the option of choosing their own form of entertainment Wednesday night, and those who preferred some other show than the French Casino would not be taxed for an affair they might not attend. Be that as it may, representatives of the French Casino will be at the Registration Desk, and it is hoped that the majority of members and guests will attend this "informal" gathering.

On Thursday afternoon and every morning there will be "plant trips" in New York City. Here it would be premature to announce plans that are still in the making by Mr. Curts and Mr. Winship, the latter being Chairman of the Ladies' Entertainment Committee. The intention is to spot the high lights of the city that would interest ceramists. Available are such features as Radio City, including a look behind the scenes at the broadcasting rooms—all of which, incidentally, are suspended in the air to avoid vibration; its air conditioning system—the largest in the world, and so on. The New York Telephone Company, with its unbelievably intricate system of switchboards and cables, including a demonstration of transatlantic telephone and broadcasting hookups; the S.S. *Queen Mary*, where the boat will be reserved on Tuesday afternoon exclusively for the ceramists, including a personally conducted tour of the ship from boilers to pilot house, ending with a tea in one of the beautiful salons. The Planetarium, of which there are only three in the United States. Further details of this program, including special features for the ladies, will be announced before the convention.

Friday will be plant trip day, in charge of Robert Sherwood, United Feldspar Corporation. Buses will leave for Trenton, Philadelphia and South New Jersey to visit factories of special interest to the members of the various Divisions.

In our opening paragraph, it was stated that the week of March 21 will be known as American Ceramic Week. A serious effort is being put forth to make this an actuality, particularly in New York City, through a publicity committee headed by Charles H. Peddrick of the United Feldspar Corporation.

The first step in this direction will be the Carborundum Broadcast, on March 13, generously donated by that company. On March 16, Dupont will broadcast over WINS a program technically known as "Questions and An-

swers." Both programs, and others yet to be arranged, will impress upon the American public that there are such things as American-made ceramics, and that the American Ceramic Industry is one of America's great industries.

Other broadcasts will be scheduled; for example, WABC (Columbia Network), over which an educational talk will be delivered during American Ceramic Week. Other programs will be announced later. A very ambitious campaign has been laid out and Mr. Peddrick's committee reports a considerable degree of success to date. Details will be forthcoming in THE GLASS INDUSTRY for April.

Glances at the programs of the general sessions and of various Divisions of the Society fall upon papers and addresses which should be of interest to glass men.

One of these is the President's Address, by Francis C. Flint, Hazel-Atlas Glass Co., who is completing an eminently successful year as the head of the Society, during which he convoyed a number of members of The Glass Division to the International Congress in England.

J. B. Vail, Philadelphia Quartz Co., who is an authority on glasses that dissolve in water, presents the second address on Monday morning, March 22, entitled, "Perspective in Relation to Research."

He will be followed by G. W. Morey, of the Geophysical Laboratory, on "Silicate Science." We may be assured that this address will be of a fundamental character, and of interest to the Glass Division as well as to any who work with ceramic materials.

In The Materials and Equipment Division, R. W. Stone, advanced geologist of the Commonwealth of Pennsylvania, reports upon the "Glass Sand Industry in Pennsylvania in 1936." Nothing of this sort has appeared since the fine monograph by Fettke, written about 25 years ago, and it should be interesting to observe what changes may have taken place in methods and product in the meantime.

In The Refractories Division, W. W. Winship, of the Thermal Syndicate, Ltd., is to read a paper on "The Refractory and Ceramic Uses of Fused Silica." Here is a glass of a highly interesting and special sort, and no doubt many of our members will want to hear it discussed by this authority.

H. M. Kraner, of Bethlehem, Pa., presents "Some Considerations in the Process of Producing Fused Mullite for Refractories." Perhaps mullite tank blocks are not under specific consideration, but the process of making them must be basically the same.

● *A. N. Finn, vice-chairman of the Glass Division.*

● *J. S. Gregorius, chairman of the Glass Division.*

In The White Wares Division, A. C. Hardy, Massachusetts Institute of Technology, has a paper on "Physical Aspects of Color and Its Measurements." While we are concerned mainly with transparent colors in distinction from most of those used on white wares, some features may be brought out which would be helpful to makers of colored glasses.

Glass Division Papers

The first part of the program is devoted largely to reports of researches of a scientific character on the properties and behavior of glass. A list of these papers, perhaps not in the final order in which they will be presented, with some comment upon their purpose and content so far as it has been disclosed by abstracts, follows:

1. **Some Observations on the Relation Between Composition and Specific Refractivity of Glass,** by A. N. Finn, National Bureau of Standards, Washington, D. C.

This is evidently a continuation of work which has already been reported, which permits the estimation or prediction of the refracting power of a glass from its chemical composition.

2. **Theory of Photoelasticity,** by Hans Mueller, Mass. Institute of Technology, Cambridge, Mass.

A study of the photoelastic constants of glasses of various compositions and of cubic crystals reveals that the photoelastic birefringence is caused by two effects. Under the influence of a compression, the distribution and arrangement of the atoms are changed. This first effect gives rise to positive birefringence. It increases with increasing index of refraction. The second effect is a slight deformation of the atoms due to pressure. This deformation alters the optical properties of the atoms and produces negative birefringence. The magnitude of the second effect varies little with the composition of the glass. For glasses with a small index of refraction, the second effect predominates. Hence, pressure produces negative birefringence in most glasses and crystals. In the heaviest flint glasses and in some crystals, however, the first effect is larger. Hence, they show a positive photoelastic constant. In some special glasses with an index of refraction of about 1.8, the two effects compensate each other, and no photoelastic effect is observed.

3. **Undergraduate Thesis Work at the New York State College of Ceramics,** by S. R. Scholes, Alfred University.

Some results will be presented and discussed, covering investigations which are not sufficiently thorough and complete to justify making them the subjects of separate papers.

4. **Effect of Annealing on the Expansivity of Some Glasses,** J. B. Saunders and A. Q. Tool, National Bureau of Standards, Washington, D. C.

Tool had previously shown that the properties of a glass depend somewhat upon its thermal history. We may expect further disclosures dealing with the peculiar "constitutional" changes (not involving the Supreme Court) that take place in that important temperature range where glass ceases to be internally mobile and becomes elastic.

5. **The Base Release of Some Commercial Glasses as Determined by Electrodialysis,** by R. M. King, Lord Hall, Ohio State Univ., Columbus, Ohio.

King might be intending to discuss why bottoms drop out of tumblers—but probably not. Instead, we may expect a new approach to the problem of measuring durability. (*Continued on page* 82)

● *The Victor Larsen Choir which will entertain A. C. S. members the evening of March 21.*

6. **Refractive Indices of Some Glasses in the Ternary System $K_2O.4SiO_2$-Fe_2O_3-SiO_2,** by G. T. Faust, Rutgers University, and A. B. Peck, Univ. of Michigan.

In the course of some phase-rule investigations of the ternary system $K_2O.4SiO_2$–Fe_2O_3–SiO_2 by the "quenching method" of Shepherd, Rankin, and Wright, the refractive indices of 30 glasses were measured by the usual petrographic immersion method. The refractivities varied from 1.438 for a $K_2O.7SiO_2$ glass to 1.621 for the most ferriferous glass which contained 32.3 per cent Fe_2O_3. The maximum FeO content reached a value of 0.33 per cent in a glass originally containing 25.0 per cent Fe_2O_3. Along the sections $K_2O.4SiO_2$, $K_2O.5SiO_2$, $K_2O.6SiO_2$, and $K_2O.7SiO_2$, the relation between the Fe_2O_3 content of the glasses and the refractive index is apparently linear. The isofracts, however, in the ternary system are curved lines.

7. **Henri Le Chatelier: His Life and Work,** by Alexander Silverman, Univ. of Pittsburgh.

Our best biographer presents the story of the late, great Frenchman whose work in pyrometry and physical chemistry places us all in his debt. Personal reminiscences will add to the interest of this recital.

And, some time during the sessions, Professor Silverman will show colored movies of the division members on the lawn at Cambridge Springs, last October.

8. **A Simple Method for Comparing the Expansion of Glasses, and Its Application to Casing Glasses,** by J. E. Rosenberg and A. Langerman, The O. Hommel Co., Pittsburgh.

The contraction of glasses between the "critical temperature" and room temperature is determined by firing the finely ground glass to an enameled steel cylindrical ring. The ring is cut at one diameter and the tensile force just necessary to part the ends of the ring is determined. This force is the function of the difference between the coefficients of expansion of the steel and the glass in the range between the "critical" and room temperature, as well as Young's modulus of the two materials. It is a simple matter to make determinations, and since the force measured depends on the differential between the expansions of steel and glass, relatively large differences in the forces are obtained for glasses having small differences in the expansion coefficients. It is found that these data can be used directly in determining the suitability of glasses for casing. Data are also given on the comparative expansions of commercial glasses.

9. **The "Sessile Drop Method for Studying the Nature of Glass-Metal Adherence at High Temperatures: I,** by B. S. Ellefson and N. W. Taylor, Pennsylvania State College.

At 1000°C drops of sodium metasilicate resting on a gold surface showed the same contact angle with the metal surface, *in vacuo*, air, or oxygen. $LiBO_3$, Na_2SiO_3, and enamel cover-coat frit spread on a platinum surface in air or oxygen but contracted to the original shape *in vacuo*. On carbon, the spreading was less than on gold or platinum *in vacuo*. Photographs illustrating these effects are shown, and a discussion is presented of the factors promoting adherence.

10. **The "Sessile" Drop Method for Determination of Surface Tension and Density of Viscous Liquids at High Temperatures: II,** B. S. Ellefson and N. W. Taylor.

An apparatus is described which allows measurements to be made of the exact dimensions of a "sessile" drop of liquid, resting on an inactive surface, at temperatures up to 1300° or 1400°C and *in vacuo*, or any desired gas medium. Under these conditions, surface tension and gravity are the only forces acting on the drop, and the exact shape, surface, and volume may be computed from the tables of Bashforth and Adams. The method may be used with liquids having viscosities up to 600 poises, whereas the bubble-pressure method as used by Jaeger is limited to liquids of viscosity less than 70 poises. On

(*Continued on page* 84)

METHOD OF REDUCING HEAT LOSSES FROM FURNACE PARTS

By A. E. BADGER

Although it may not be advisable to insulate the refractories of glass tanks which are subjected to severe corrosion, there are many parts in which the use of insulation is justified from an economic standpoint. Such insulation is usually accomplished by means of various materials which are applied to the hot surfaces as a plaster, or in metal containers, or by other devices.

A different method of insulation consists in the use of a sheet of material which is placed a short distance from the hot surface and acts as a reflector for the radiant heat which is emitted from the furnace wall. A good reflector which is readily available is sheet aluminum, although certain sheet irons are suitable also. These materials have been used for the thermal insulation of refrigerators, ships, houses, etc., for some time.

When a sheet of some material as aluminum metal is placed a short distance from a hot surface, the temperature conditions before and after the installation may be visualized as in Fig. 1, in which T_1 represents the hot inner surface of a refractory and T_4 the room temperature. Fig. 1 illustrates the fact that insulation has raised the temperature of the outer face of the refractory from T_2 to T_2', the magnitude of this increase being dependent on the nature and the amount of the insulation which has been applied. The heat losses per unit area of surface in these cases are as follows:

$$\triangle H = \frac{T_1 - T_2}{d} K, \text{ and}$$

$$\triangle H' = \frac{T_1 - T_2'}{d} K',$$

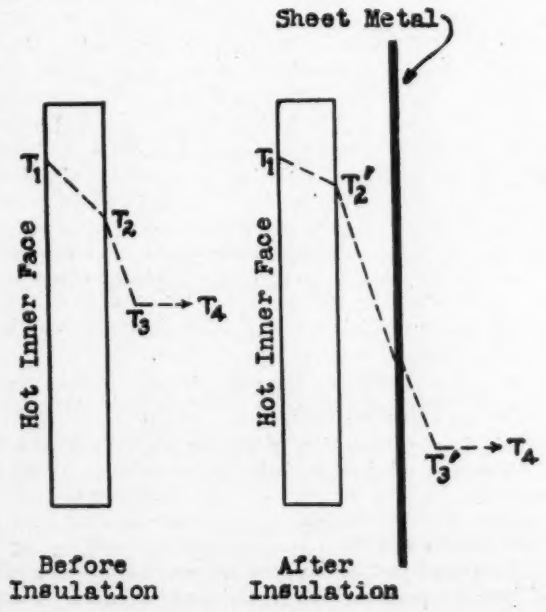


Fig. 1

where d is the thickness of the refractory, while K and K′ are the mean thermal conductivities in the given temperature ranges.

The use of sheet metal for the purpose of heat insulation brings up a question regarding the optimum separating distance between the hot refractory surface and the sheet. This distance may vary from zero, as when a metallic paint is applied to the surface, to greater values. However, experiments have shown that a stagnant air film exists over a hot surface for about ¼ inch from that surface. In other words, referring to Fig. 1, the horizontal distance from T_2 to T_3 is about ¼ inch. Therefore, a separation of about ½ inch between the hot surface and the sheet metal should produce good results. Under these conditions, the air layer between the refractory surface and the sheet is nearly motionless, convection losses approach zero, and radiation losses are greatly reduced by the heat reflecting metallic surface.

In order to determine whether metallic sheets would be useful for insulating some parts of high temperature industrial furnaces, a section of the side walls in the working end of a large glass tank were chosen for test[2], since such parts could be assumed to have a constant temperature on their inner faces. Corhart refractory blocks were being used in this furnace, for which thermal conductivity data were available. Two sets of tests were made: one in which aluminum sheet was used with a ½-inch separating air space, while in the other test aluminum paint was applied directly to the surface of the block. Each test was made on a selected part of the wall, extending 36 inches horizontally along the wall and 30 inches vertically up from the bottom blocks.

The method of test was to measure the surface temperature of the refractories by means of two thermocouples which were attached to the surface of each test panel near the mid-area. Surface temperatures were measured in this way both before and after applying the insulating material. From these measurements and thermal conductivity data, the heat saving due to insulation was computed.

The results of the temperature measurements are summarized in the following table:

Insulating Material	Couple Number	Temperature of Block Surface, °C		
		Before Insulation	After Insulation	Temp. Rise
Sheet aluminum with air space	1	403	750	347
	2	308	708	400
Aluminum Paint	3	359	427	68
	4	295	365	70

Computations from the above measurements and thermal conductivity data gave the following results:

1. The use of sheet aluminum decreased the heat loss about 49 per cent.

2. The use of aluminum paint decreased the heat loss about 8 per cent.

These results proved the value of aluminum sheet as a heat insulator for parts of high temperature industrial furnaces. Although tests were not made on the regenerators, it is probable that insulation of these parts would be the greatest field of usefulness for metallic sheet insulation of glass tanks. The sheet could be suspended from the top of the regenerator walls and could be easily removed and replaced. The customary method of insulation by the use of low conductivity materials has the advantage of sealing the regenerator walls and preventing filtration through them.

The test in which aluminum paint was applied directly to the block surface indicated that a small reduction in heat loss can be brought about by this means. This method may be useful in those cases where the application of other insulation is inconvenient or impossible.

[1] Published with the permission of the Engineering Experiment Station, University of Illinois.
[2] These tests were made by the staff of the Pitney Glass Works, General Electric Co., Cleveland, Ohio.

PLANS FOR A. C. S. CONVENTION

(*Continued from page* 82)

the basis of internal evidence, the surface tension values obtained by the sessile-drop method are considered correct within 5 per cent. They also agree with data by Jaeger, but are (roughly) twice as great as those of Washburn and Libman, who used a ring method. The probable sources of error in Washburn's work are discussed. The application of surface-energy data to the calculation of limiting strengths of glass in tension is discussed briefly.

11. **The Strength of Glassware and the Validity of the Gaussian Curve,** by F. W. Preston, Butler, Pennsylvania.

The variations in the strength of glass specimens, nominally alike, are very great. The "normal curve of errors" (e^{-x^2} type) is usually assumed to be applicable to the case, and results are commonly based on that assumption. Theoretically, the curve cannot be applicable, and the question of how near to the truth it may be must be determined experimentally. As the subject has important practical and legal aspects, it has been investigated for some important cases.

12. **Some Comments on the Constitution of Glass,** by W. Weyl, Dept. of Ceramics, Pennsylvania State College.

The different types of glass-forming processes such as (*a*) silicate and inorganic glasses, (*b*) organic glasses, and (*c*) condensation products with some vitreous properties are discussed. Normal and associated liquids, factors leading to high viscosity and long relaxation time, stabilized and non-stabilized glasses, and anomalies in the softening interval are also mentioned. Methods for determining the dissociation-association processes in glass and their dependency upon temperature, heat treatment, and mineralizing agents are given. Some of the applications to glass technology of the present picture of the structures of glasses are (1) color problems, (2) gas solubility, (3) fiber stability, etc.

13. **Elastic and Viscous Properties of Several Soda-Silica Glasses in the Annealing Range,** by N. W. Taylor and P. S. Dear, Pennsylvania State College.

Anyone who has seen a piece of ware bounce on the factory floor while it was still soft enough to squeeze out of shape with tongs, will see no contradiction in this title. The authors are using very simple glasses in their study of what goes on as viscosities approach infinity.

14. **The Analysis of Test Data Obtained in Tensile Strength Measurements** (Tentative), by James Bailey and A. Lyle, Bailey & Sharp Co., Inc., Hamburg, N. Y.

These authors are hard-headed and penetrating enough to spike whatever fallacies there are in the mass of conflicting data on tensile strength.

15. **Effect of Certain Oxide Additions on the Surface Tension of Glass,** by A. E. Badger and C. W. Parmelee, Univ. of Illinois.

A report is given on the effect of additions of various glass-forming oxides on the surface tension at 1200° and 1350°C of a soda-lime glass. Determinations were made by the Jaeger maximum bubble-pressure method as modified by Parmelee, Lyon, and Harman.

16. **Diffusion of Helium and Hydrogen through Pyrex Chemically Resistant Glass,** by N. W. Taylor, W. L. Rast, and Paul L. Smith, Pennsylvania State College.

The rates of diffusion of helium gas through Pyrex-brand glass in the temperature range 200° to 600°C have been measured. Glass under strain (unannealed) shows a lower rate of diffusion for He than does the annealed glass, although the strained glass has a lower density. Between 450° and 600°C, the diffusion rate may be expressed by the relation $\log R = A - B/T$, the heat of activation being 7150 calories per mol. The straight line representing these data shows no break at the so-called transformation point of the glass as determined by expansion measurements, 550 ± 10°, and it is believed that this point has no unique significance as to glass structure or constitution. Below 450°C, the diffusion rate is expressed by a similar equation when the heat of activation for this range is 6400 calories per mol. At a temperature of 452 ± 2°, the glass undergoes an apparent structural change. The probable meaning of this is discussed. The effect of annealing for one month or longer at temperatures near 400°C is to increase the rate of helium diffusion, due probably to the reduction of stray electrical fields of the ions in the glass by ionic rearrangement. The relation between gas pressure and diffusion rate has been carefully investigated at four temperatures for helium and at two tempratures for hydrogen. In all cases, the rate is directly proportional to the gas pressure. The hydrogen appears to diffuse as molecules rather than as atoms or ions. It is believed that the mechanism of diffusion is essentially chemical rather than "crack diffusion" or effusion in the ordinary sense. From the standpoint of problems of glass structure, gas diffusion appears to offer considerable promise.

17. **Crystal Structure of Sodium Metaborate, $NaBO_2$,** by Ssu-Mien Fang, Ryerson Physical Lab., Univ. of Chicago.

This paper criticizes and revises data obtained by x-ray methods by previous investigators.

18. **Some Studies on Reactions between Glasses and Phosphate Solution,** by Arthur S. Watts and J. B. Brown, Ohio State Univ.

This is a continuation of studies partially reported last year on the behavior of glasses exposed to an unusual reagent.

Glass Symposium

The second part of the program consists not so much of formal reports and the recitations of data as of more

(*Concluded on page* 93)

OPTICAL SOCIETY MEETS IN CORNING

The convention of the Optical Society of America in the Steuben Hotel, Corning, N. Y., March 4-6, will be based primarily on the many applications of optics in the glass industry and the contributions of the glass industry to optics. Most appropriately, the Corning Glass Works will open up its several plants so that members of the Society may readily obtain a first hand view of the extremely close relationship between optics and glass.

The morning of March 4 will be devoted to advance registration and to generally getting acquainted with Corning. The Wellsboro plant of the Glass Works will be open all day to visitors. This plant, which is located on route U. S. 6, manufactures incandescent lamp bulbs by high speed automatic machinery.

While it is not possible to present all of the papers to be read at the sessions, abstracts of two of the papers to be read the morning of March 5 will be of particular interest to glass men.

Changes in the Atomic Arrangement of Glass During Cooling.[1] By Howard R. Lillie, Corning Glass Works.

A true glass apparently consists of a network of atoms, the randomness of which depends upon the intensity of thermal agitation. Atom bonds are quite distorted at all temperatures, their regularity never being of such an order as to constitute crystallites. During cooling, the decrease in thermal agitation allows the atoms to approach statistically their desired positions. The viscosity partly determines the speed of this approach, the required rearrangement taking place rapidly at high temperatures but slowly at low temperatures. A certain temperature, depending upon the cooling rate, will appear, above which the lag between temperature and atomic rearrangement is negligible and below which the lag is appreciable. This critical temperature is usually in the annealing range. Heat treatment at any temperature below the critical one must cause a progressive change in physical properties as the atoms approach nearer to the ultimate statistical equilibrium condition determined by that temperature. Changes in such properties as refractive index, density, expansion coefficient, electrical conductivity, elastic modulus, and viscosity are shown. These properties indicate that the temperature uniquely determines the final state, which is approached from one direction or the other, depending on previous thermal history. Extended viscosity tests made by fiber elongation and stress release tests made by optical methods are described. Results indicate that if we take into account the variation of viscosity with time at constant temperature, then the rate of stress decrease is proportional to the first power of the stress rather than to the second power as concluded by Adams and Williamson[2], who assumed that the physical properties were constant.

The Effect of Heat Treatment on the Refractive Index of Glass. By A. Q. Tool, L. W. Tilton and J. B. Saunders, National Bureau of Standards.

In a paper read[3] at the Ithaca meeting of the Optical Society of America in 1925 it was shown that the index of refraction of glass as determined under the usual standard conditions can be increased by lowering the annealing temperature, and can also be decreased correspondingly by raising that temperature. Since that time the investigation has been extended to a number of glasses, and the changes obtained in the indices per degree Centigrade change in the annealing temperature have in part been published in the annual reports of the Director of the National Bureau of Standards. Meanwhile Lebedeff,[4] Stozarov,[5] and others have been pursuing similar investigations. Stozarov, in particular, investigated several optical glasses and has shown by series of index determinations made without breaking the annealing process how the index slowly approaches definite values which vary with the annealing temperature. The glasses investigated at the National Bureau of Standards include not only the optical glasses currently produced there but also eight of its earlier melts for which optical data and batch compositions are published in the Smithsonian Physical Tables (p. 358, 8th ed.). Tentative results for the sensitivity of refractive index to annealing temperature have been obtained from index measurements made on these glasses at 25°C. For sodium light these sensitivities (per 1°C) multiplied by 10^5 are 2.9, 5.5, 3.0, 4.4, 2.6, 5.5, 2.7, and 3.0, respectively, for the melts 103 (123) 241, 135, 116, 188, 151, 163, and 76. In three cases (melts 151, 163, and 123) the original prisms used in obtaining the data in the Smithsonian Tables were not available. Duplicate samples of the first two were obtained, but there was some indication that the optical properties had not been uniform throughout melt 163. No sample of melt 123 was found. In its stead one from melt 103, which had about the same batch composition and production date, was tested.

After the reading of four other technical papers, the meeting will adjourn to a complimentary luncheon given by the Corning Glass Works and a trip through their main plant. Following an informal dinner in the evening, there will be demonstrations of detection and measurement of strains by means of polarized light.

After the reading of technical papers the morning of March 6, there will be two plant visits scheduled for the afternoon. At the Fall Brook division of the Corning Glass Works, members of the Optical Society will witness the automatic drawing of glass tubing, and at the fibre products division they will see something of the manufacture of glass fibres for insulating and other uses.

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[1] The present paper will appear in full in the Journal of the Optical Society of America.
[2] L. H. Adams and E. D. Williamson, "The Annealing of Glass." J. Frank. Inst. 190, 597-631, 835-870 (1920).
[3] Tool, Tilton, and Hill, J. O. S. A. and R. S. I. 12, 490 (1926).
[4] A. A. Lebedeff, Revue d'Optique 5, 1 (1926); Die Glas Industrie 35, 6 (1927).
[5] A. I. Stozarov, Trans. Opt. Inst., Leningrad, 4 (No. 39), 1-36 (1928).

G. C. A. TO MEET, MAY 20-21

The annual meeting of the Glass Container Association will be held at the Greenbriar Hotel, White Sulphur Springs, W. Va., May 20-21. The general session will take place Thursday morning, May 20, with the annual golf tournament in the afternoon and the annual dinner in the evening. A meeting of the Glass Division is scheduled for Friday morning. Cap Division members are expected to meet on Wednesday, the 19th, and it is announced that a directors' and several committee meetings will probably be held the same day.

J. M. Foster, who started the first Stoddard Factory, 1842.

George W. Foster, New Granite Glass Works, Stoddard, 1858.

Adelbert M. Foster, late president, Foster-Forbes Glass Co.

John M. Foster, present president, Foster-Forbes Glass Co.

STODDARD GLASS

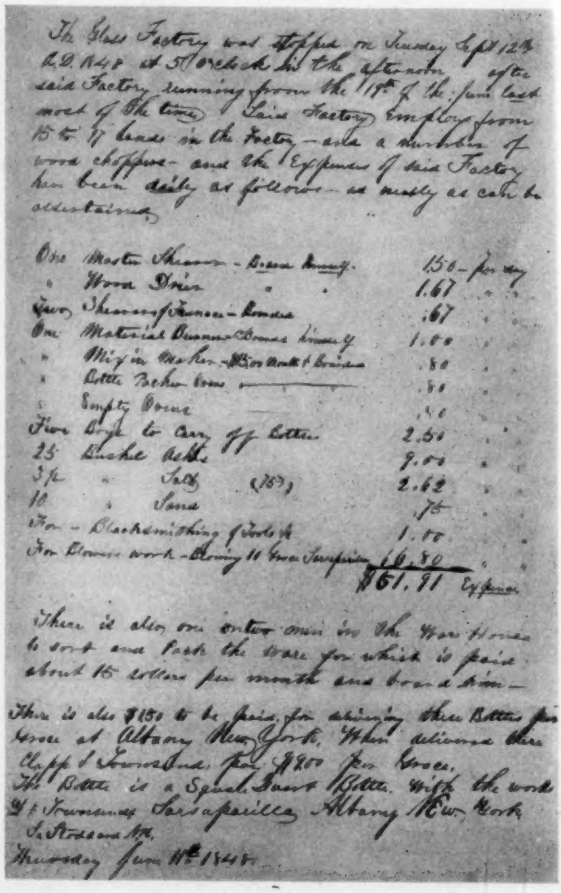
Much has been written about the glass factories of Stoddard, N. H., which were started about 1842. Several factories were operated within a 30-year period in this little village, which is near Keene. The product of all of these factories was bottles, blown from the crudest glass, the batch for which consisted of wood ashes, salt and sand. Crude as the quality may appear to us now, there was a certain beauty to this old glass, most of which was golden amber, while some was a peculiar green. The workmanship was for the most part excellent, particularly for those times. Specimens of genuine Stoddard bottles are now rare and are highly prized by collectors of old or antique bottles.

Fuel used to heat the glass in the pot furnaces was wood, cut from the forest, dried and transported to the factories by oxen. The finished product was also hauled in ox-carts into Keene and other large towns for distribution, there being no other transportation facilities available. For this reason especially Stoddard factories had difficulty in competing with other bottle factories, which were more advantageously located.

Joseph Foster started the first glass factory in Stoddard in 1842. He was familiarly known as "Old Bottle Foster." He was born in Hartley Pans, England, May 2, 1801, where he learned the art of glass blowing. After coming to this country he began blowing bottles in Keene, N. H., and it was from there that he came to Stoddard to start in business for himself.

His first factory proved none too successful, but later he established a second factory; the daily expense sheet, dated June 11, 1848, is reproduced on this page.

It will be noted that many of the employees were "boarded," while others "furnished oxen." The cost of the glass batch consisting of ashes, salt and sand is also shown therein. The bottles being produced at the time (note center bottle on page 87) were Square Quart Sarsaparilla bottles, with the words "Dr. Townsend's Sarsa-



The Glass Factory was stopped on Tuesday Apl 12th A.D. 1848 at 5 o'clock in the afternoon — the said Factory running from the 18th of the June last most of the time. Said Factory employs from 15 to 17 hands in the Factory — and a number of wood choppers — and the Expenses of said Factory has been daily as follows — as nearly as can be ascertained.

One	Master Shearer - Board himself	1.50 per day
"	Wood Driver "	1.67 " "
Two	Shearers Furnace - Board	.67 " "
One	Material Drawer Board himself	1.00 " "
"	Mixer in the Room - Board & Lodging	.50 " "
"	Pot Setter Board himself	.50 " "
"	Empty Boy	.50 " "
Five	Boys to Carry off Bottles	2.50 " "
25	Bushel Ashes	3.00 " "
3	" Salt (85)	2.62 " "
10	" Sand	.75 " "
For	Blacksmithing & Tools	1.00 " "
For	Glass work - Blowing 11 Gross Sarsaparilla	10.50 " "
		$61.91 Expenses

There is also one extra man in the Wood House to sort and pack the Ware for which is paid about 15 dollars per month and board him —

There is also $150 to be paid for shipping three Bottles per Gross at Albany New York. What allowance there Clapp & Townsend pay $3.00 per Gross. The Bottle is a Square Quart Bottle. With the word D. Townsends Sarsaparilla Albany New York. L. Stoddard N.H.

Thursday June 11th 1848

Daily expense sheet for the Granite Glass Works. The bottle, made and covered by this list of expenses, was a square quart bottle for Dr. Townsend's Sarsaparilla.

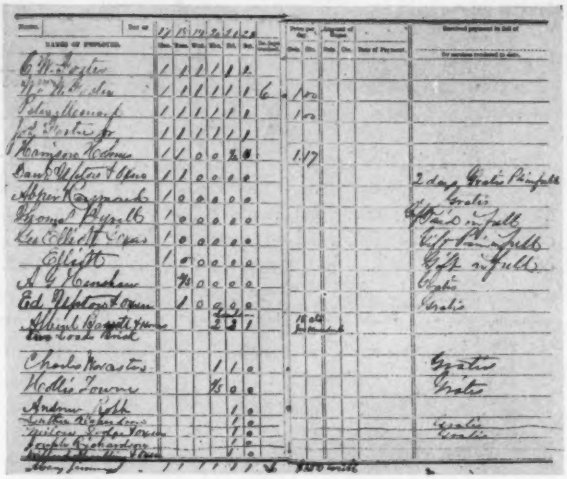
parilla, Albany, N. Y.," blown into the glass. Of interest also is the price—$9.00 per "groce" delivered Albany, N. Y. About 1850, Joseph Foster sold his factory to Scripture, Whiton and Curtis, who operated the furnace in conjunction with their own factory already established in Stoddard. The firm was known as the Granite Glass Works.

Joseph Foster's sons, George, Charles and Wallace, had been raised in the glass business and about 1858 George W. Foster started the *New* Granite Glass Works in Stoddard. He managed the factory, while his brothers were employed as blowers. A younger brother, Joseph, had charge of making rattan and wicker casings for the larger bottles and demi-johns. Reproductions of an inner page of the original leather-bound payroll book and a picture of the interior of the blowing room, which was made from an old daguerreotype, are shown.

The factory apparently operated successfully until about 1870, when the Foster Brothers sold out to Charles B. Barrett, a Boston liquor dealer. In 1871 the factory burned to the ground.

Another factory, owned by Weeks and Gilson, was operated quite successfully in Stoddard from about 1853 to 1872. Apparently, shortly after 1870 glass manufacturing in Stoddard came to an end. Several of the factories had burned and were never rebuilt probably because of the inaccessibility of Stoddard to the markets and also because clear glass bottles were becoming very popular. It is evident that the sand, and other raw materials available there, were unsuitable for the manufacture of these clear "flint" bottles. Factories were beginning to spring up in the mid-west region, where coal could be used for fuel, and later the advent of natural gas simplified the problem of heating the glass furnaces, which had to be contended with by the early New England manufacturers.

From the time Joseph Foster started the first glass bottle factory in Stoddard to the present day, the Foster family has been in the glass business continuously. Joseph's son George left Stoddard about 1871 when his New Granite Glass Works burned and he went to Boston. There he founded the firm of Dean, Foster and Company. In 1885 his son, Adelbert M. Foster, went to Chicago, opening a branch and operating under the firm name of A. M. Foster & Company, at the same time becoming interested in and founding several Indiana bottle plants, including the Marion Flint Glass Co., the Sheldon-Foster Glass Co., the Millgrove Glass Co. and the Upland Flint Bottle Co.



A page from George W. Foster's Payroll Book for the New Granite Glass Works. Several employees furnished oxen and horses.

Interior of blowing room of New Granite Glass Works made from an old daguerreotype now in J. M. Foster's possession.

In 1929 the name of the Upland Flint Bottle Co. was changed to the Foster-Forbes Glass Co., of which A. M. Foster was president when he died on December 22, 1934. His long-time associate, William C. Forbes, who had just succeeded him to the presidency, died April 1, 1935.

A. M. Foster's son, John M. Foster, great-grandson of Joseph Foster, is now the president of the company, and hence is the fourth generation of Fosters in the glass bottle manufacturing business—1842-1937—a period of ninety-five years.

A group of Stoddard bottles. The center bottle, for Dr. Townsend's Sarsaparilla, Albany, N. Y., is the one covered by the daily expense sheet dated June 11, 1848, of the Granite Glass Works operated by Joseph Foster.

POLAROID TESTED BY GENERAL PUBLIC

Typical of the widespread public interest in polaroid is the demonstration of this glass at the New York Museum of Science and Industry in the RCA Building, Rockefeller Center. Here visitors to the museum can be seen making experiments of their own with polaroid and such pieces of glassware as test tubes, vacuum tubes, flasks, etc., and studying strain distribution under varying loads.

THE ARGENTINE AS A MARKET FOR AMERICAN GLASS

By DuWAYNE G. CLARK*

Argentina is the largest Latin American market for imported glass products. In 1935 this trade was valued at 9,099,293 pesos (approximately $2,630,000 based on official exchange 1935 rate, one peso equals U. S. $0.289) of which the United States supplied slightly more than one per cent (159,347 pesos).

ARGENTINE IMPORTS OF GLASS AND GLASS PRODUCTS — 1935

(Values in Pesos)

By Country of Origin

Belgium	3,855,823
Czechoslovakia	1,709,651
Germany	1,485,657
United Kingdom	1,269,307
France	343,825
United States	159,347
Japan	137,744
Others	137,930
Total	9,099,284

By Commodities

Common glass up to 2 millimeters	1,362,696
Common glass more than 2 millimeters	1,771,039
White or colored glass of all thicknesses	1,106,151
Glass for skylights	266,901
Glass for skylights with wire	197,897
Fine glass up to 87 x 61 centimeters, unsilvered	418,837
Other fine glass, unsilvered	2,189,378
Glass insulators	23,573
Electric light fixture glass	219,283
Lenses for glass	96,882
Bottles of common glass without tops	41,343
Bottles of polished glass	66,323
Bottles with glass stoppers	21,511
Glass tubing	38,201
Other glass and crystal	961,087
Other articles of glass and crystal	318,191

An analysis of the statistics shown above reveals that Belgium, Czechoslovakia, Germany and the United Kingdom supply the bulk of the lucrative market. Flat glass for windows and mirrors and fine glass for lenses and eye glasses are the leading items in this trade. With the exception of this flat glass and glass novelties, the Argentine domestic glass industry is able to supply most of its other glass requirements. There are, of course, a few highly specialized products that are not strictly subject to the price consideration, but the amount of business to be done in this category is not large nor is it likely to increase to any extent.

Previous to 1931, when the Argentine exchange control was introduced, the United States exported a considerable amount of glass to this market. Since then, however, the control scheme and the later addition of a tax of 20 per cent on all imports not covered by an advanced exchange permit has almost completely forced this trade out of its normal channels. Exporters in the United States found it impossible for their local representatives to secure official exchange permits while imports from European sources, especially Belgium, apparently experienced no difficulty in securing these permits. As a consequence of this condition, American glass has been at such a disadvantage in so far as price is concerned that it has practically disappeared from this market for the time being. In 1935 our total United States exports of glass products to Argentina were valued at less than $75,000, as compared with over $300,000 in 1930. If the Argentine Government should decide to do away with this control it should again be possible for American manufacturers to quote competitive delivered prices and their business should improve. The development of the local flat glass industry should not prejudice the position of imported plate glass for some time, as the local plant will, no doubt, concentrate upon the development and the production of the simpler grades before attempting the more complicated processes.

The actual competitive situation between the Argentine industry and foreign suppliers can be easily visualized by comparing sales figures; that is, imports represent approximately 9 per cent in value of sales over an annual period, domestic manufactures accounting for the balance. This 9 per cent does not include window glass, lenses, other flat glasses, etc., purchased from foreign sources which is not directly or indirectly competitive with the Argentine industry. However, this 9 per cent amounted to some 1,630,000 paper pesos during 1935 and to a certain extent is representative of articles bought at favorable exchange rates, or specialized products which at that time were not being produced locally. The generally improved economic situation in Argentina, especially noticeable during the past year, has made its influence felt in all lines of trade, manufacturers are viewing the future with more security, and it is understood that during 1936 sales made by the domestic producers showed a distinct gain over the share of business held by foreign suppliers during the previous year.

Argentine Manufacture of Glass

The manufacture of glass in Argentina began, according to the most reliable sources of information, in 1880 when a number of dealers and importers banded together, formed what would now be known as a cooperative establishment, and started production which amounted to something like 200 pounds of glassware a day. The absence of sufficient capital, and the rather contradictory ideas represented by the various owners of the small plant, prevented the natural course of development and soon after its opening it was decided to sell the machinery equipment, and accessories to a man who established a new factory in Belgrano, a suburb of Buenos Aires, and who can probably be considered as the true founder of the glass industry in Argentina.

The usual difficulties of a new enterprise confronted the first Argentine glass plant, not the least of these being the problem of securing adequate supplies of raw materials. The organization prospered, however, and was the parent of a present day company. In 1896 a second factory was established which is operating today. At a later date other companies such as Cristalerias Papini Hermanos; Piccardo, La Asuncion, Magnini,

* Assistant Commercial Attache at Buenos Aires. Released through the courtesy of the U. S. Bureau of Foreign and Domestic Commerce.

Bolognini and several other plants were started.

Due to severe competition from overseas manufacturers, principally European, the progress of the local producers was comparatively slow. Protection through the application of import duties was requested, but only hesitantly granted. However, when the Great War started, the usual sources of supply were closed to importers. They were forced to turn to the local manufacturers to a large extent and this situation naturally gave the domestic industry a tremendous stimulus, it secured practical control of the market, and has retained it ever since. The introduction of fuel oil as a furnace heating agent also helped the industry at about the same time.

The progress made by the local industry can possibly be best illustrated by a comparison between figures pertaining to the years 1914 and 1935. Of the 19 factories reported in operation during 1935 one was started that year. Of the total, 13 were located within the bounds of the Federal Capital, and the remaining 6 in the Province of Buenos Aires.

	Year 1914	*Year* 1935
Number of plants	16	19
Invested capital	5,835,000 pesos	12,052,812 pesos
Value of production	4,254,000 pesos	15,436,705 pesos
Value of raw material consumed	1,265,500 pesos	3,602,368 pesos
Employees	2,136	3,923
Motive force employed	269 H.P.	2,128 H.P.

During the year 1935, the latest period for which detailed statistical information is available, the industry paid out in salaries and wages a total of 5,575,302 pesos. Of raw material consumed, valued at 3,602,368 pesos, there was imported from foreign sources more than 41,849,665 pounds, while the domestic industry supplied more than 134,569,657 pounds.

The range of products of the industry is comparatively wide, including all types and kinds of glass bottles, flasks, containers, bulbs, tableware, and similar articles. According to the Direccion of Commerce and Industry of the Ministry of Agriculture, the following production was realized during the year 1935, representing a total value of some 15,436,705 pesos.

Albumen meters	No.	264
Alcohol meters	No.	220
Soda siphon bottles	No.	38,768
Tubes for other hypodermics, etc.	No.	4,465,249
Laboratory material	No.	15,990
Areometers	No.	1,242
Cheap bazaar goods	Lbs.	7,959,299
Bottles	No.	5,578,261
Small bottles and flasks	Lbs.	45,404,029
Burettes	No.	5,850
Butyrometers	No.	4,677
Canulas	No.	57,640
Goblets	No.	968,000
Demijohns	No.	200,000
Densimeters	No.	2,774
Flasks	No.	458,800
Flasks	Lbs.	2,750,000
Jars	No.	33,500
Syringes	No.	56,000
Hypodermic syringes	No.	74,000
Florence flasks	No.	470
Measures	No.	44,000
Must meters	No.	212
Nipple shields	No.	6,000
Pipettes	No.	23,543
Coolers (refrigerants)	No.	106
Milk extractors	No.	5,000
Condensers	No.	88
Decanting siphons	No.	30
Liquid Silicate Soda	Lbs.	3,520,000
Jars	No.	27,000
Thermometers	No.	5,812
Tubes for various purposes	No.	2,352,813
Urea meters	No.	344
Tumblers	No.	638,000
Miscellaneous	No.	1,154,849
Miscellaneous	Lbs.	13,111,263
Construction glass	Lbs.	2,200,000

Only a very limited amount of flat glass is now manufactured in Argentina, these products consisting of such articles as small panes for covering electric light meters, gas meters, etc. Another product of some importance is a pressed glass brick employed in the construction of walls and floors. Up to the present there has been no manufacture of either window glass or roll glass, but it is understood that a plant is now under consideration which will, when completed, turn out such lines. Some 80 acres of land near Lavallol have been purchased as a site for the new factory, plans are well under way, and within a few months this new activity should be in operation.

It is estimated that the domestic industry manufactures and supplies from 90 to 95 per cent of the requirements of the Argentine trade in bottles. The general classification including such items as beer, vermouth, sherry, wine and whiskey bottles, as well as those commonly employed in connection with non-alcoholic preparations such as ginger ale, fruit juices, soda and the like. Bottles are made in all types and shapes, all colors of glass, from a half pint size to the two and four liter bottles, and 10 and 15 liter demijohns.

The small bottle or prescription ware trade is also almost completely dominated by the domestic industry. In a few cases special bottles for such luxury articles as perfume are imported, but by and large the trade is confined within the country, as the industry produces a

●Once the Argentine was an excellent market for American glassware. But the introduction of an exchange control system and the imposition of heavy taxes placed the United States at a great disadvantage, and much of our Argentine trade went to Belgium. Today, out of a total of over 2½ million dollars of imported glass we are supplying a mere 1 per cent.

All of which holds great significance in view of the recent Buenos Aires conference, and the reciprocal trade agreements that are now being negotiated with the Latin America countries. It is quite logical to expect that these treaties will remove the barriers to American trade—not only in Argentina, but throughout the whole of South America. And conversely, we may expect to see our own markets opened to foreign competition.

This impending redistribution of commerce—definitely one of the Administration's objectives—makes it necessary for the American glass manufacturer to seek foreign markets, both to expand his trade and to offset domestic losses that are sure to result from reciprocal treaties. To help the American manufacturer—to inform him where opportunities exist, to tell him of foreign customs and trade usages, to arrange contacts, and guide him carefully through a type of transaction with which in many cases he is not entirely familiar—Thomas Burke, Chief of the Specialties Division of the Bureau of Foreign and Domestic Commerce, has offered the services and facilities of the United States Government. His plan is to link the facilities of the Specialties Division to the glass industry through a committee appointed by and representative of each and all of its branches.

The Specialties Division is most efficient and effective. Its chief is a practical business man, experienced in foreign commerce. The setup presents an ideal opportunity for glassmen to derive much profit and to further stabilize their business, through export channels. It is to be hoped that Mr. Burke's plan will be given every possible consideration.

wide range not only for perfumes but also for pharmaceutical items and extracts.

Under industrial ware, the domestic industry turns out wide mouth ware, pressed, and pressed and blown articles, including bottles for dairy products such as milk, cream, and liquid cheese, for honey, jams, meat extracts and other food products as well as confectionery. Under this heading may be mentioned as well, glass containers for cosmetics in sizes and colors, including Opaline glass.

The range of domestic manufacturing covers a wide variety of form, colors and grades of glass. The more common items are cocktail and liquor sets, punch bowls, decanters, fruit bowls, dishes, plates, tumblers, goblets, pitchers. Sets of these products are available in all prices, the cheapest being about 2.00 pesos for a set of 26 pieces, fabricated of common glass. More elaborate and expensive ware is to be had in half crystal sets, plain, pressed, cut, engraved, etched, decorated with enamel, or hand painted. Needless to say, the domestic industry is the principal and controlling factor in this trade, although a certain amount of competition results from the importation of cheap glassware from central European sources, especially Czechoslovakia.

Globes for lighting purposes, either alcohol, gas, or electric current, are produced locally. The industry, as will be noted from the list of manufactures, also turns out glass tubing, tubes for vaccines and medicinal preparations, syringes, measures, thermometers, and many other articles of a somewhat specialized character.

GLASS IN ARCHITECTURE COMPETITION

Because both public and professional interest in the use of glass in construction has made it desirable to coordinate in easily accessible form the outstanding work in this line, the Pittsburgh Glass Institute, 30 Rockefeller Plaza, New York, has announced a competition to be based on executed examples of glass in architecture, decoration and related subjects. The competition is open to all architects, designers and decorators, and all entries must be in by April 30.

Unlike many architectural competitions, entries are to consist of photographs of completed work, not drawings of projected designs. While excellent photographs are desirable, the basis of the competition is glass design, not photography. All work to be eligible for entry must have been completed between Jan. 1, 1936, and March 31, 1937. Entries will be classified as residential, commercial, industrial, public and general. The last classification is open to all examples showing glass when not used as an integral part of the building. In other words, objects made completely of glass and suitable for use in buildings but not in themselves a part of a building.

The winners of the first, second and third awards in any of the 11 classifications will be presented with a finely engraved glass medallion designed by Sidney Waugh, an eminent sculptor in glass. Owners of the building or property receiving awards will be presented with suitably inscribed certificates.

● *The medallion, designed by Sidney Waugh for winners of the Pittsburgh Glass Institute competition, is of finely polished glass, 4½ inches in diameter and approximately ½ inch in thickness. The design, in intaglio on the reverse side of the medal, shows the competition symbol engraved in exquisite detail.*

PERMANENT TENSILE STRESSES IN GLASS — A CORRECTION

While rewriting from his rough draft of the above titled article, which appeared in the February issue of THE GLASS INDUSTRY, the author of this paper inadvertently switched the expressions "lower in expansivity" and "higher in expansivity." The first paragraph of the second column on page 42 should therefore read: "If the cord consists of glass *higher in expansivity*. . . . The reverse action takes place when the cord is *lower in expansivity*."

Cords or flashings lower in expansivity than the main body of glass will not contract as much as the mass of glass and thereby tend to prevent the contraction of the main body of glass giving rise to compressively strained cords or flashings.

The author wishes to thank Dr. F. W. Preston for calling this error to his attention.

CERAMICS COURSE AT PENN STATE

The Division of Mineral Industries Extension of the Pennsylvania State College is now preparing to offer a program of adult education to workers in the ceramic industries. It has prepared a three years' course of study designed to give the worker in the plant the training necessary for him to assume positions of greater responsibility, to handle better the new processes developed by research and to correlate his practical understanding with the technical aspects of the industry.

The first two years are largely preparatory to an understanding of the subjects which the student may elect to study in his third year, when he will have a choice of any of the following: Refractories, Heavy Clay Products and Whiteware, Glass and Enamels, Portland Cement, Limes and Plasters.

Since July 1, 1936, Edward P. McNamara has been preparing an outline of the course as well as copy for a first year textbook to be used in this course. The textbook will be ready and courses are planned to start in the latter part of September, 1937.

JANUARY PLATE GLASS PRODUCTION

The production of polished plate glass by member companies of the Plate Glass Manufacturers of America was 6,373,282 square feet in January, as compared with 7,371,236 square feet produced in December, 1936, and 17,275,632 square feet produced in January, 1936.

THE BATCH AND CORDY GLASS

"Improper raw materials, incorrectly mixed batch, demixed batch and other items concerning the glass batch are among the primary causes of cordy glass." In spite of the fact that the glass chemist has been preaching the above gospel for the past 15 years or more, it is rather surprising to find that the majority of cordy glass troubles may be traced back to the causes quoted above. This state of affairs is probably due to the fact that the plant superintendent takes the operation of the batch room more or less for granted and devotes the greater part of his time to machine problems. A review of the relationship between cordy glass and the glass batch is therefore worth while, as it will serve to show that this phase of glass manufacture cannot be neglected if one wishes to continually produce usable glass.

Considering the raw materials first, it is not necessary that their composition be that of the ideal material as small departures from the theoretical can usually be successfully compensated for by the plant chemist. It is important, however, to have the supply of raw materials uniform from shipment to shipment. If marked variations occur in shipments it is usually not possible to make the necessary corrections in the proper manner, with the result that cordy glass may often be caused by such variations. For example, if the raw material storage bins are such that several carloads of material are on hand at one time, composition variations in different shipments of a material will cause the development of strata of varying composition material in the bin. As these different compositions of material are mixed into the batch the resulting glass will be variable in composition and cordy glass may result.

Uniformity of chemical composition is fairly easy to obtain in the case of manufactured raw materials such as soda ash, borax, and the like. In the case of naturally occurring raw materials uniformity is more difficult to attain, especially in cases where different deposits are supplying the material in question. In many cases, however, the supplier is able to blend his product and is able to supply a material constant in composition. In cases where this cannot be accomplished and the glass manufacturer must depend upon several different deposits the only remedy is the use of separate bins for the product of each deposit. Chemical control and supervision thereby becomes a necessity if variable composition materials are to be correctly utilized. While this presents a high cost, the elimination of losses due to cordy glass down-times, developed through the use of variable composition raw materials, more than balances the initial and upkeep costs of such control.

Constancy of composition also includes factors such as the moisture content of the raw materials, drying of damp raw materials and the pickup of moisture and carbon dioxide through accident or during normal storage. Even though the supplier is shipping material that has proven to be constant in composition, leaky freight cars may be used which, if shipped during a rainy spell, will allow the material to pick up excessive amounts of moisture. If such material is used without correcting for its moisture content the difference in weight may be great enough to cause serious differences in the composition of the resulting glass. Likewise, if wet sand is used, large variations in the weight of sand actually in the batch will result when no attempt is made to keep the moisture content constant. With materials which will pick up moisture and carbon dioxide during storage, it is always well to systematically run the storage bin empty at intervals. If this is not done there will always be some material that will remain in the storage bin for long periods, gradually increasing in volatile content and which will sooner or later be worked into the batch. Constant checking of the moisture content of the various materials when received, while in storage, and before use is necessary if accurate control of the glass composition is to be assured.

Somewhat related to constancy of composition is the accidental mixing of different raw materials while in storage. If the storage bins are properly constructed, intermixing of the materials through leakage will seldom occur. If wooden structures are used, this type of contamination often takes place and constant checking of the condition of the bins is necessary. The prevention, of course, is the construction of leak-proof storage facilities. In the modern type of storage system intermixing of the raw materials is usually due to the human element. If the unloading of the cars is not properly supervised, indifference or carelessness on the part of the man sending the raw materials from the car to the storage bin will often result in the material being unloaded into the wrong bin. Such a mistake is usually not noticed until the glass goes bad. Fool-proof unloading systems, proper supervision and training of those responsible for the unloading of the raw materials will prevent such mistakes.

The weighing and the mixing of the batch are two items that cannot be neglected when cordy glass causes are being considered. In many cases of cordy glass the final analysis of all of the many factors involved usually points to either one or the other of these two items. In the case of the weighing of the batch raw materials, most semi-automatic systems are so constructed that no provision is made for the batch mixer to correct an overweight condition. In manual systems, the correction of an overweight condition is left to the integrity of the batch mixer. In either case the final result is that the weight is not corrected and the overweight material is fed into the mixer.

In manual systems the only method of preventing such a condition is the careful training of the batch weigher in the importance of his job. In the semi-automatic system a means for correcting overweights should be provided and recording scales installed as a check on the actual amount of each material being weighed. Recording scales will show not only overweights and underweights, but also errors of omission. If each scale is equipped with a suitable recording device a tabulation of each weight and the number of weights at the end of each mixing period will give an excellent check on the performance of the batch mixer. Such a system will eliminate many of the headaches that accompany cordy

glass troubles as a glance at the records will quickly show if off-composition batches have been fed into the doghouse. Without a record of the actual amounts of material weighed up, it is almost impossible to be sure that the weighings were faulty, as a cross examination of the batch mixer usually yields little worth-while data.

Many times the human element is not at fault and improperly weighed batches are the result of mechanical troubles in the batch scales. When the batch scales are connected with, or are a part of, the batch mixer, the continual jarring and vibration present in the mixer will often throw the batch scales out of balance. Systematic checking of the scales against standard weights or the re-weighing of a known weight of material or a set of standard scales is necessary in such cases, if accuracy of the batch weighings is to be assured. Where recording devices are used, it is necessary to systematically inspect and check such devices if reliance is to be placed in their records. The procedure usually followed where recording type scales are used is to weigh standards at the beginning and the end of the mixing period or if mixing is continuous, the standards are weighed at fixed intervals. The weighings are thereby subjected to a continuous check and variations due to off-balance scales are quickly noted.

Turning to the mixing of the batch, it is well known that an intimate mix cannot be obtained if the different materials comprising the batch are greatly different in grain size. With the exception of the cullet this difference in the grain sizes of the various materials is no longer as troublesome as it was several years ago as the raw material manufacturers are now producing materials that have grain sizes approaching the grain size of the sand used in the batch.

With cullet, however, the problem is very serious in plants using large amounts of foreign cullet. When cullet of their own manufacture was used, it could be introduced into the furnace without regard to its grain size and in many cases without mixing it with the batch, and the consequences were never serious. With foreign cullet, which invariably is somewhat different in composition from the glass produced from the batch, it is no longer possible to just crush the cullet to any size, mix it with the batch in variable amounts or just shove it in the doghouse. If homogeneous glass is desired, it is necessary to crush foreign cullet to a comparatively small size and to intimately mix it with the batch, maintaining a definite proportion of cullet to batch.

The care taken to insure correctly mixed batch can quickly be nullified if precautions are not taken to prevent segregation or demixing of the batch during its travels from the mixer to the doghouse. The best advice that can be given in regards to the prevention of demixing is that excessive handling of the batch should always be avoided. If the handling system is such that the batch reaches the doghouse by a series of "drops" and "pick-ups" the chances are that demixing will take place at every drop.

As the design of batch conveying and storage systems vary widely from plant to plant no single set of rules governing their correct design or operation can be drawn. Regardless of the type of system used, a good first step in tracing down the cause of a cordy glass condition is to first check the batch handling system for demixing.

BAUSCH & LOMB RESEARCH ACTIVITIES

A broad program of fundamental investigations on the chemistry and physics of glass surfaces to aid in the development of scientific apparatus and ophthalmic instruments has been started at the Mellon Institute of Industrial Research, Pittsburgh, by the Bausch & Lomb Optical Co. The new studies will be concerned with the effects of environmental factors on the durability of the various types of glass used in optical instruments. Dr. Frank L. Jones, the fellow in charge since 1931, will also be in charge of the new activities.

Developments in the past have included improved greases for optical instruments, cements for ultraviolet transmitting optics, improved methods for making and testing mirrors and reflectors, and standardization of the sizes of fine abrasives used in grinding lenses.

Concurrently with the beginning of new researches at the Mellon Institute, it is interesting to note that Bausch & Lomb has opened a new laboratory for applied research in Rochester at a cost of approximately $40,000 and with a 50 per cent increase in its staff of graduate chemical engineers and metallurgists.

BELGIUM ADOPTS FOUR-SHIFT SYSTEM

Beginning Jan. 1, 1938, a four-shift system will be utilized in automatic window glass works in Belgium, according to a report from the Brussels office of the U.S. Bureau of Foreign and Domestic Commerce. This change in working regime was brought about by royal decree when Belgium ratified the decision taken by the International Labor Conference at Geneva in June, 1934, instituting the four-shift system. According to the report, this regime limits the working hours in continuous operation to 42 hours and an eight-hour day.

It is not expected that generalization of the four-shift system will cause great difficulties in Belgium, for it has been in partial operation for several years. Glass works employing the Fourcault system are already working on this basis with the personnel occupied in non-stop operations. Other glass works are said to be using the system for operators, apprentice-operators and gallery supervisors. In addition to these facts, companies who have not hitherto utilized this system will have almost a year in which to adapt themselves.

S. LEE LEBBY IS DEAD

With great regret, the GLASS INDUSTRY records the very sudden death of S. Lee Lebby on February 19. Since 1922, Mr. Lebby has been head of the Optical Development Division of the Corning Glass Works. His loss will be felt, not only by his business associates and his many friends in the glass industry, but also in the town of Corning, N. Y., where he was a most active church and civic leader.

BAIRD MARBLE HEADS LATCHFORD

Subsequent to the death of W. J. Latchford, president of the Latchford Glass Co., Los Angeles, the following officers were elected. Baird Marble, president; W. J. Latchford, Jr., and J. T. P. Macdonald, vice-presidents; M. L. Ashby, secretary.

Effective on or about March 1, the general offices of the Illuminating Engineering Society are to be moved to 51 Madison Ave., New York.

THE CHEMISTRY OF COLORED GLASS

(*Continued from page* 78)

ramics have a dark red color due to small amounts of iron which are present. Other samples which contain a greater amount of iron are only faint brown. The deep red color of garnet and of some salts of the Stassfurt type differ widely from the well known color of iron compounds.

In all the above-mentioned cases, the factor which determines the type and intensity of the color effect is the coordination number of iron and of chromium. A systematic study of these relationships would not only be of scientific interest but would undoubtedly considerably increase the series of pigment colors for glazes and enamels. (*To be continued in the April issue*)

FRENCH CASINO PARTY

Famed for the pulchritude of its entertainers, the French Casino is to be the location of a supper party to be held at 10:30 P. M. Wednesday evening, March 24, for the members of the American Ceramic Society. The minimum charge is $3.00 per person and will include beverages or food as desired. An attendant will be on hand at the reservation desk of the A. C. S. in the Waldorf-Astoria to make reservations, which may be secured by paying $1.00, this amount to be applicable on the $3.00 minimum check.

PLANS FOR A. C. S. CONVENTION

(*Continued from page* 84)

general discussions on physical testing, particularly on that being done in the instance of the American Society for Testing Materials.

The first paper gives the "Results on Tensile Strength Tests Obtained by the Division's Committee," headed by Dr. J. T. Littleton of Corning. We hope that Dr. Littleton will be able to present this paper in person. If not, he will delegate someone to take his place.

James Bailey offers "Notes and Suggestions on Tests for Thermal Endurance of Glass," calling attention to the intimate relationship between this property and tensile strength, and the inevitable effect upon thermal endurance of those same factors which give rise to so much variability in measurement of tensile strength.

S. R. Scholes will report on "Some Recent Tests on Thermal Endurance," covering two distinctly different types of glass, and making use principally of specimens in the form of rods of several sizes.

L. B. Tuckerman, National Bureau of Standards, discusses the question of "What Hardness Is, or What Hardness Is Not." It will be recalled that this problem was attacked in three different ways by investigators who reported at the 1936 meeting, with the result that the atmosphere was left somewhat cloudy with respect to terminology. Whether hardness means resistance to scratching, superficial strength, or resistance to abrasion, or perhaps none of these, is something that we look to Mr. Tuckerman's discussion to specify.

Finally, the relation of The Glass Division to other technical societies will be discussed as follows:

"The Work of The Glass Division and Its Relation to the Needs of:

(a) "The Illuminating Engineering Society by H. H. Blau, Macbeth-Evans Glass Div., Charleroi, Pa.

(b) "The Society of Heating and Ventilating Engineers, by R. A. Miller, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

(c) "The American Society for Testing Materials," by W. C. Taylor, Corning Glass Works, New York.

J. S. Gregorius, of the Research Laboratory of the Pittsburgh Plate Glass Co., Creighton, Pa., will preside as chairman of the Division in this final meeting of a year under his successful leadership.

GERMAN CERAMISTS TO VISIT A. S. C.

One of the most pleasant outgrowths of the International Congress on Glass in London last summer is the plan of some 30 members of the German Ceramic Society (Deutsche Keramische Gesellschaft) to visit the United States during the convention of the American Ceramic Society in New York this month. Arriving in New York on March 19, the group will attend the A. C. S. meeting on the 21st and 22nd, and depart for Trenton, N. J., the morning of the 23rd and make a series of visits to plants and other points of interest to ceramists.

For the benefit of those who may wish to welcome the German group, following is the proposed itinerary: March 24, Baltimore; March 25, Washington to inspect the Bureau of Standards and the Geophysics Laboratory of Carnegie Institute; March 27, 28 and 29, Pittsburgh; March 30 and 31, Chicago; April 1 and 2, Detroit and Flint, Mich.; April 3, Buffalo; April 4, Niagara Falls; April 5, Syracuse or Corning; April 6, Schenectady, and April 7 sail from New York for Hamburg.

THOMPSON JOINS HARBISON-WALKER

Dr. Clyde L. Thompson has become associated with the Harbison-Walker Refractories Co. as a member of its research staff. He is thoroughly experienced in petrography and his work as a consultant in that field is well known. He has also done considerable work on thermal expansion of refractories by the interferometer method and on refractories used in glass tanks. Dr. Thompson is a graduate of the University of Illinois in Ceramic Engineering, holding the degrees of B.S. (1927), M.S. (1930), and Ph. D. (1936). He was on the teaching staff of the Department of Ceramic Engineering, University of Illinois, from 1928 until his affiliation with the Harbison-Walker Refractories Co. During that period, he made many interesting and valuable contributions to the technical literature.

● *Dr. Robert B. Sosman will deliver the Orton Memorial Lecture at the coming meeting of the American Ceramic Society on the subject of "Pyrometry and the Steel Makers Refractories."*

EQUIPMENT AND SUPPLIES

IDENTIFY BATCH MATERIALS

A novel idea has just been introduced by the United Feldspar Corporation, New York, for the better identification of each of their batch materials. In addition to labeling their Chemi-Trold products, they are packing them in different colored bags. This is designed to eliminate the possibility of introducing the wrong chemical into the batch during the mixing process. For example, feldspar is now packed in a red bag, pyrophyllite in blue, quartz in a light brown bag, Carolina stone in green and Tru-Mix in an orange bag.

CYANAMID ACQUIRES STONE

The American Cyanamid & Chemical Corporation, New York, has announced the acquisition of the business and plant of Chas. H. Stone, Inc., Charlotte, N. C., whose operations will be merged with those of Cyanamid's Southern District. The Charlotte district, under the direction of Paul F. Haddock and Chas. H. Stone, will be located at 822 West Morehead St. The Greensboro, N. C., warehouse will be at 125 Walker Ave., and the Greenville, S. C., warehouse at 409 Westfield St.

BOTTLE TESTING SCALE

Six interesting and useful suggestions as to the proper method of utilizing their bottle and mold testing scale have been received from the Exact Weight Scale Co., Columbus, Ohio. They are as follows:

1. To weigh avoirdupois use cylindrical nickel weights and use beam reading in avoirdupois. Put bottle or object on left platter and weights on right platter, if object is greater than one ounce. Graduated beam will give weight of object one ounce or less in 100ths ounces, by balancing front poise. For this operation the back poise must *always* be on balance.

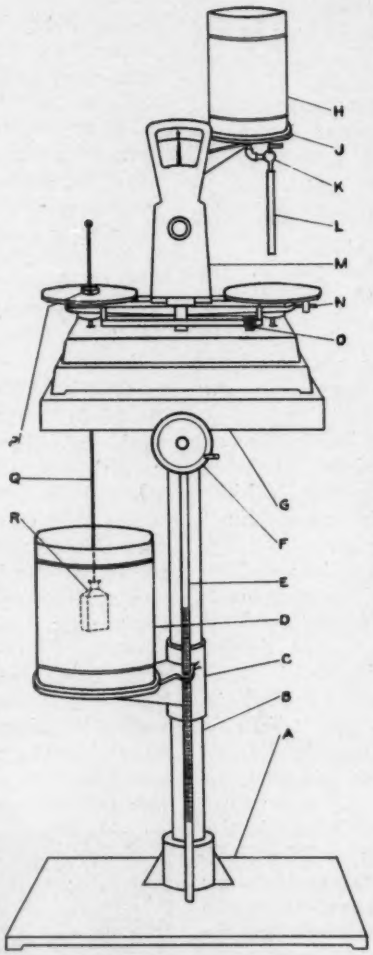
2. To weigh fluid ounces in a bottle or any other container, put object on left platter and balance scales by moving back poise to the right. If bottle or container is heavier than back poise use cold rolled balance weights in addition to back poise. Front poise must rest at extreme left. Then weigh contents by moving front poise to right using the fluid ounce side of beam. Placing hexagon weights on right platter, if contents are more than one fluid ounce.

3. To use the metric system of weights and measures proceed exactly the same as in case of the avoirdupois and fluid ounces except that the cylindrical brass weights and side of beam marked grams should be used.

4. To weigh cubic inches also proceed exactly the same as in case of avoirdupois and fluid ounces but use the square brass weights and beam marked cubic inches.

5. To find the displacement of a glass bottle fill the bottle with water and hang it on the bottom end of the rod running through the right platter. but not touching the water in the tank below. Then balance scales by placing cold rolled weights on left platter and moving back poise to the left for the final and fine adjustment. Be sure that front poise is resting at the extreme left end of the beam. Now displace bottle by lowering bottle with contents into tank below being sure to have it completely immersed. The results can be obtained in any of the four denominations, namely, avoirdupois ounces, fluid ounces, grams or cubic inches (however, the avoirdupois ounces in the case of displacement would not be used).

6. To displace a wooden model, sulphur or lead cast proceed exactly the same as in case of the glass bottle, except that there are no contents to deal with.



● *Bottle and mold testing scale. A. base; B. pedestal; C. displacement tank; D. displacement tank support; E. elevating screw rod; F. elevating screw rod control; G. supporting base for scale; H. auxiliary tank; J. auxiliary tank support; K. stop cock; L. rubber tube; M. Exact Weight Scale No. 460; N. balance ball; O. triple reading revolving beam (avd. oz. fluid oz., cubic inches); P. mold specimen rod stop; Q. mold specimen rod; R. mold specimen.*

UNIVERSAL'S NEW OFFICERS

Universal Crushing Co., Cedar Rapids, Iowa, have elected a new group of officers in keeping with their expansion policy in the field of crusher equipment, portable washing and screening plants and accessory handling equipment. Those elected are: A. W. Daniels, president; H. F. Rikhoff, secretary and treasurer; L. S. Hackney, sales manager, and L. W. Dunlap, assistant general manager.

A hand operated cup and bottle banding machine has recently been developed by the O. Hommel Co., Pittsburgh. From hairline bands up to any size desired can be successfully worked either in solid form or in design at the rate of between 10 and 15 objects per minute.

CATALOGS RECEIVED

Tag Laboratory Thermometers and Hydrometers. Catalog No. 1100A. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y. In addition to the regular line of precision and standard grade thermometers and hydrometers, this new catalog includes complete listings of the widely used A. S. T. M. thermometers with illustrations. Comparison scale graduations, corrections for emergent stems, instructions for using hydrometers and fahrenheit and centigrade comparison tables are included.

Materials Handling Equipment. Circular No. 321. Lewis-Shepard Co., Watertown, Mass. A small colored folder just issued on the subject of equipment for handling barrels, drums, carboys, cases, cartons, etc.

A New Motorblower Type CS. Bulletin No. 2310. Ingersoll-Rand Co., Phillipsburg, N. J. Data on a new unit designed to meet the needs of services requiring air at one pound pressure and in volumes from 325 to 3200 cubic feet per minute. These motorblowers are said to be particularly suited to industries where oil or gas fired furnaces are used.